Applying and Managing PBL
An Experience in Information Systems Education

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Abstract: The dynamism of the global economy and its growing dependence on Information Technology, more complex and integrated, has required a transformation in the education of software professionals with the focus on the development of skills such as teamwork, real practice of problem-solving, managerial profile and analysis of solutions. In this context, the Problem-Based Learning (PBL) approach falls as a glove for the training of professionals in these competencies. From this motivation, this paper describes the application of the PBL approach in an Information Systems course. Aiming the effectiveness of this approach, the Framework described in (Santos and Rodrigues, 2016) was applied, which proposes tools for the planning, execution, monitoring, and improvements of PBL. The results showed the suitability of the Framework for this purpose, describing how it was applied and how the PBL can be managed, besides emphasizing main benefits and improvement points from this application.

1 INTRODUCTION

The education of the professionals in Computing area has undergone several transformations to adapt to the demands of the labor market, in the face of continuous technological changes and increasingly complex and integrated applications. One of the main changes concerns to need of holistic view of different subjects, prioritizing educational objectives based on the development of skills and abilities, rather than knowledge about isolated content disconnected from practices. This change is reflected in the most recent versions of the main curricula in the Computing area ACM/IEEE Computing Science (Draft, 2013) and ACM/IEEE Software Engineering (ACM/IEEE, 2015), which stand out as principles the real problem-solving ability, project management experience and the ability to critically analyse solutions. All of these principles are multidisciplinary and developed from the work in group and real labour experiences.

From this motivation, this paper describes a case study of an Enterprise Management Systems (EMS) course, part of an undergraduate course in Information Systems (IS). In order to align the purpose of this course to labour market demands, we chose to adopt the Problem-Based Learning approach (PBL), considering its increasing popularity in this area (Martin, 2005), (Tuohi, 2007), (Peng, 2010), (Zaharias, 2012), (Oliveira, Santos and Garcia, 2013), (Panwong, 2014), (Santos, Figueiredo and Wanderley, 2013), (Santos, Furtado and Lins, 2014), (Santos, Alexandre and Rodrigues, 2015).

PBL is defined in (Savery, 2006) as an instructional method of teaching and learning, which is able to develop the ability to apply diverse knowledge to solve problems, through teamwork and individual attitudes as self-initiative, critical vision and reflection of the learning process, conforming its principles. Its dynamics are very different from traditional learning, where students usually work on projects far from the reality of the market, under conditions and restrictions imposed by the teacher (teacher-centered approach), which aims to explain a large amount of content and consequent low practical application. In PBL, students are the center of the learning process, and if the problem being solved and the learning environment are authentic, more prepared for the professional reality the students will be. In addition, the skills and abilities developed in PBL are consequences of intense collaborative and investigative work. In traditional teaching, students tend to work individually, often with little interaction and knowledge sharing. This process does not favor the

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development of interpersonal skills such as communication, leadership, planning, but focusing almost always in technical knowledge. Computer students acquire knowledge in technologies, processes and development methods, while the interpersonal skills, important to solve problems, are little explored.

The authors of this paper also understand that for an effective PBL approach it is necessary to preserve its principles and manage its processes throughout learning cycles, within an essentially practical environment. Despite the benefits of PBL, evidences identified in (Oliveira, Santos and Garcia, 2013) indicate that there are difficulties regarding the application of PBL and verification of its results. The lack of knowledge about the methodological fundamentals of PBL, aligned with disjointed ideas about the operationalization of the method, common in innovations, are aspects that contribute to low interest and incoherence in its application.

In order to provide support to PBL implementation, the few available proposals have been focus on different aspects of the "problem element”. For (Hung, 2006) problem-building needs to gain more attention because aligning the quality of problems with learning objectives is a challenge that has an effect on learning. The author presents the 3C3R model as a conceptual framework for the conception of problem ideas. The model name highlights central components related to C's (content, context, connection); and R's (researching, reasoning, reflecting) as processing components. The central components have the function of establishing a basis for the definition of the problems, and the processing components aim to facilitate the students' involvement in the resolution process. Even if this artifact can contribute to the planning stage, there are no considerations regarding the management of the application of the problem and follow-up of the learning. Having effective problems by component descriptions does not make the teaching and learning process effective, even if it is one of the factors that contributes to the results. In (Hung, 2009), the author proposes a process for designing problems in nine steps. This process is indicated to assist in the application of the 3C3R model. Another solution to be highlighted is the VU-PBL framework used by Victoria University in Australia for computing science and engineering courses. The VU-PBL framework consists of four main components: key elements, PBL principles, PBL cycle and PBL levels. The key elements are four (problem design, facilitation, engagement and evaluation). They make up the central part of the strategically defined cycle for the effective implementation of PBL. In order for each element to be effectively considered in the implementation, ten principles are distributed among them. The cycle is intended for the student, who can lead learning process through seven steps. The cycle and its steps are similar to the PBL process defined by Barrows (2002). In fact, these solutions highlight isolated parts of the implementation process of the PBL, with few operational and managerial supporting to this approach, considering the entire management cycle.

In order to ensure a manageable implementation of the PBL approach, this case study uses a PBL framework for computer teaching published in (Santos and Rodrigues, 2016). This framework proposes the management of PBL in learning cycles based on the Management Cycle of Deming (Plan-Do-Check-Act), supported by processes and artifacts that facilitate the planning, execution, monitoring and realization of continuous improvements along the teaching and learning process. From this study it was possible to understand the importance of a management process that allows: to plan PBL based on essential elements; to execute the learning process supported by continuous evaluations and feedbacks; and to improve the learning process along the course.

2 THE FRAMEWORK BY-CYCLES

In (Santos and Rodrigues, 2016), the authors defined a framework to apply PBL in teaching of Computing. This framework aims to facilitate the management of teaching processes in the PBL approach through techniques and management models. Intended for the pedagogical team, this instrument indicates a set of actions that need to be considered at each step of the Plan-Do-Check-Act cycle of Deming (as shown in Figure 1), relating roles and responsibilities to the actors for an effective application of the PBL approach.

The components of this framework are: 1) xPBL (Santos, Furtado and Lins, 2014), as a methodology specific to the framework that considers techniques and management tools; 2) PBL-Process, as a PBL process consists of steps that help conduct the methodology, as well as steps to encourage the student to the learning process; 3) PBL-SEE (Santos, 2016) as an authentic assessment model to verify the student's performance, PBL and teaching process; 4)

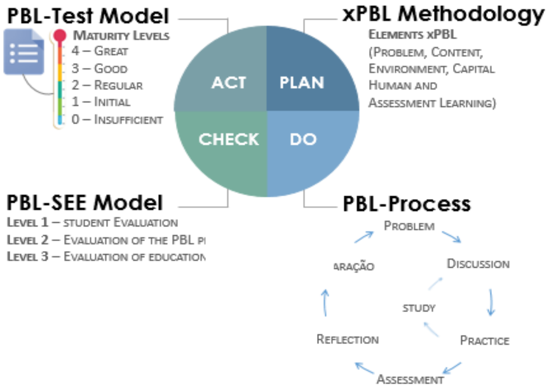

Figure 1: Steps of PBL Framework.

PBL-Test, process maturity model in PBL. The following sections highlight component details and their relationship to the framework steps.

2.1 Plan: xPBL Methodology

Based on the principles of the PBL approach, xPBL considers management techniques to facilitate the implementation of the teaching process (Santos, Furtado and Lins, 2014). Purposely, the five elements that make up the xPBL defined to ensure adherence to the principles process, envision characteristics necessary for the PBL process. The elements refer to: 1) *Problem*, an essential aspect in learning in this approach, reflects realism and complexity similar to real contexts; 2) *Environment*, related to the definition of an authentic learning environment that reflects the actual context of the professional market; 3) *Human Capital*, with evidence to the roles and responsibilities of the pedagogical team in the planning, execution and follow-up of the process; 4) *Content*, as an essential part to support the theoretical basis of the problem solving process, consistent with the context of the problem; And 5) *Processes*, for the adequacy of evaluation processes inherent to the learning format in PBL. Thus exposed, consider the planning process xPBL requires consider and define aspects of the five elements.

According to the authors, a plan of action guided by the 5W2H technique sees to it that the five elements are defined in a clear and organized way because they obtain answers to questions such as: "What?", "Who?", "Where?", "When?", "Why?", "How?" and "How much?". As an effective management technique, 5W2H sees to it that activities associated with each xPBL element are broken down, analysed and summarized during the planning stage. The authors objectively considered information about what should be done and when, or who will conduct a certain activity and when, while they were defining each element.

2.2 Do: PBL-Process

The PBL-process was set to meet the dynamics of learning in PBL. With immersive learning characteristics in problem solving practices, have a process to run consistently the learning cycle becomes essential. The PBL-process is a seven step process for an iterative execution of learning cycles: 1) *Preparation*, the pedagogical team defines specifications of the methodological context and learning environment; 2) *Problem*, step for presentation of real problems by real clients; 3) *Discussion*, when student groups can identify solution possibilities supported by the Delisle resolution process (Delisle 1997) And raise learning needs; 4) *Practice*, possibility for application of methods, models, theories to the problem context; 5) *Study*, moment to meet the learning needs identified by the group; 6) *Assessment*, opportunity for verification of learning and skills development; And 7) *Reflection*, in-depth analysis of different aspects of the learning process. During a learning cycle, it is important to note that steps 3, 4 and 5 do not necessarily take this order. A team can, for example, identify the need for the study before the practice or, if they already have conditions, practice immediately.

2.3 Check: the PBL-SEE Model

As a model aligned with PBL, its use is indicated for software engineering since it is based on valuation models processes used by software industry professionals (Santos, Figueiredo and Wanderley, 2013). In this case, the Check step of the framework is supported by this component in order to verify if the learning objectives were completely achieved, but also the process faithfully adheres to the PBL principles. In summary, the model is composed of three levels: student evaluation (level 1), evaluation of the PBL process (level 2) and evaluation of education (level 3).

For level 1, five perspectives are considered: 1) Content, for the possibility of verifying the appropriation of knowledge acquired by the students throughout the resolution process; 2) Process, as indicative to verify the ability to apply knowledge in the resolution process defined by the team; 3) Result, from the delivery of solutions (products) created to address the context of the problem; 4)

Performance, through the subjective analysis of interpersonal characteristics by the students (self assessment) and their team (peer review); And 5) Customer satisfaction, when considering an evaluation from the perspective of the client, with criteria for the defined solution and aspects directed to the performance of the team.

Level 2 of the model uses the PBL-Test as described in the following subsection.

Finally, level 3 focuses on getting information about the planning and teaching program, from the perspective of the students. At this level, the teacher is also evaluated under criteria that refer to skills inherent in teaching practice, as well as ethical aspects.

2.4 Act: PBL-Test Model

In the Framework, the act step maintains focus on the continuous improvement of the PBL process from the application of a test called "PBL-Test" (Santos, Figueiredo and Wanderley, 2013), in order to identify possible methodological deviations that may render the fidelity of the approach unfeasible. This model is based on the need to evaluate the maturity of the PBL process regarding the execution of its principles, aligned to level 2 of the PBL-Test model.

In this case, a test with ten questions of multiple choices, referring to the principles, must be filled under the optics, perception and experience of human capital. For each evaluation, a score of 0 to 10 points can be obtained. All the answers are computed from an arithmetic average of the scores to generate the test result and thus identify the level of maturity of the process: 1) level 0 or insufficient (average <7); 2) level 1 or initial (7≤ general average <8); 3) level 2 or regular (8 ≤ general average <9); 4) level 3 or good (9 ≤ general average <10); and 5) level 4 or excellent (general average = 10). Once the level is identified, it is up to the PBL tutor, along with the pedagogical team, to identify strategies that can be implemented considering the principles that have had the most impact in the execution of the PBL process.

This assessment becomes effective when at least more than two verifications are performed in the running learning cycle so that improvements can be implemented in a timely manner. By the recommendation of the model, all the human capital defined by the pedagogical team, students and coordinators, needs to be involved in this evaluation.

3 METHOD

The guidelines for the scientific method which shapes the different stages of this research study, can be found in Design Science Research (DSR), a research method which involves analyzing the use and performance of artifacts that are designed to understand, explain and improve the behavior of specific factors in the domain of Information Systems (Vaishnavi, 1999). The basic principle of DSR is that the knowledge, understanding and problem solving are acquired in the construction and application of an artifact within the context of a specific problem. In this context, the DSR method was adopted in five steps:

1) *Understanding the Problem* to obtain a clearer understanding of PBL, its principles and characteristics that, in the view of several authors, govern the PBL method. It was possible to identify the challenges and any particular obstacles that might face the PBL method. As a result, a list of problems regarding the management of PBL was highlighting, such as the following: how to apply a PBL approach, the difficulty of setting out a procedure to assist the students with problem-solving, the complexity of assessment, among other factors.

2) *Suggestions step* was to make conjectures about how processes and management models can be used to facilitate the application of PBL approach. After this, it was possible to design a model for PBL planning (Santos, Furtado and Lins, 2014) and an assessment model aligned to this planning (Santos, 2016). As a result, a conceptual model of the Framework was originated (Figure 1).

3) *Development step* was to define the PBL Framework, considering all steps of the PDCA cycle. This led to the design of a maturity model of PBL based on its principles (Santos, Figueiredo and Wanderley, 2013) and propose a PBL process to support the solving-process by students.

4) *Assessment step* was to understand the preparation, application and analysis of the artifacts, together with the end users, with the aim of determining, in the first moment, the applicability of the Framework. This resulted in the setting out of improvement in Framework components along several experiences of use (Monte, Rodrigues and Santos, 2013), (Santos, Furtado and Lins, 2014), (Santos, Alexandre and Rodrigues, 2015), (Santos and Rodrigues, 2016).

5) *Conclusion stage* was to understand what we learn. It should be mentioned that the assessment procedure foresees future cases.

4 EXPERIENCE REPORT

The Framework PBL was applied in an Enterprise Management Systems (EMS) course, part of an undergraduate course in Information Systems (IS). This course has a total of 60 hours distributed in 4 months. The objective of the course was to enable students to design and implement management information systems, considering their requirements for business success. The course had 29 students with a mean age of 20, 3 were female and 26 were male.

The following subsections describe the application of the Framework in each PDCA steps, emphasizing the main interventions related to PBL managing in this course.

4.1 Planning

Regarding the PBL planning, the five elements of xPBL were considered.

With respect to the *learning environment*, 29 students were divided into 7 teams: 3 teams with 5 students; 2 teams with 4 students and 2 teams with 3 students. Of the 29 students with a mean age of 20, 3 were female and 26 were male. The criteria for team formation were: professional experience, professional interest (manage, model solutions or program) and the identification of the profile of the student (artisan, guardian, idealist and rational), being identified by the application of the simplified version of the MBTI - Myers-Briggs Type Indicator (Myers 1980). To support the communication process and facilitate the distribution of course educational materials, the following tools have been adopted: Google Drive and WhatsApp group. Each team was able to freely choose the process of planning and managing their project. The only request of the pedagogical team to the students was to make possible the monitoring and follow-up via WEB of the planning and development of the projects. For planning, six teams adopted the Trello tool and one team adopted the Pivotal tracker tool. For development teams used Google Drive as a repository of documents. As for the classroom, it consisted of a blackboard, besides to individual chairs, which could be grouped together to facilitate group work. Although the ideal environment needs to have the same configuration of work environments in the industry, it was not an obstacle to running the course. The students still had five laboratories inside the Computer Center with computers to carry out their activities.

About the *problem* definition, the pedagogical team tried to identify real projects with business partners of the respective university, seeking possible clients to bring their real problems to the teams. As a way to meet the educational goals and competencies associated with the course, the teaching team oriented potential clients that the problems to be presented should be concern to the Enterprise Management Systems context. During the second week of class, three invited clients came to the classroom and presented a set of real problems which the teams could freely choose the one that interested them the most. All clients were managers in the implementation of business management systems, one of them SAP partner.

Considering the *human capital* involved, the teaching staff of the course called the pedagogical team consisted of one teacher and two tutors (one PBL tutor, and one technical tutor). In general, tutors aimed to continuously support the teaching-learning process of students. Specifically, the role of the PBL tutors was to support the execution of the xPBL methodology (Santos, Furtado and Lins, 2014) used in the course. And the technical tutors had the function of supporting the students in the specific subjects of the course. During class, there was always the presence of at least one PBL tutor and a technical tutor attending the project follow-up meetings. Complementing the human capital of the course, there was the role of the project manager who was a student belonging to his respective team and elected by the team itself. The other members of the team worked in the role of developers of management systems. Finally, the real client was an IT professional with real and specific demands on business management systems.

The *content* that was worked on in the discipline served as support for students throughout the problem solving process. The main reference of the content was the book Management Information Systems (Laudon and Laudon, 2004). Moreover, in order to present the concepts of the PBL approach, a lecture on PBL and its principles was given to the students. Then a lecture and a dynamic on the problem solving process according to the Delisle model (Delisle 1997), another lecture on critical success factors in the implementation of management systems and finally a lecture on stakeholder management.

Finally, the evaluation *process* was applied in all dimensions of the PBL-SEE (Santos, 2016). Here, only two dimensions are presented: the first one related to students assessment (Content, Process, Results, Performance and Customer Satisfaction);

and the second dimension with focus on degree of maturity of the PBL approach, from the perspective of students, and the use of PBL-Test model. The results of these evaluations will be further detailed in section 3.3.

4.2 Doing

In order to help students to better understand the problem chosen and propose a more adequate solution to it, was developed a dynamic that made use of Delisle problem-solving model (Delisle 1997). The model is composed of four aspects that must be observed: 1) Ideas: possible solutions to the problem; 2) Facts: information about the problem; 3) Hypotheses, identification of learning problems to solve the problem and; 4) Plan of Action: strategies, information resources and other information that lead to the resolution of the problem.

Once the understanding of the chosen problem was clearer, each team had to formalize the problem describing it in some ways such as the context of the problem, its causes and complexity, the target audience, customer needs, and so on. To help in describing the problem, were given to the teams a questionnaire model that reflected these aspects. Teams were also asked to describe their initial proposals for solutions through questions that guided students about the criteria for evaluating possible solutions, problem solving strategies, needed resources, and benefits for the client.

The Enterprise Management Systems (EMS) course was conducted over four learning cycles, with the respective goals:

- 1st. Cycle (*Understanding the problem*): the objective of this cycle was to evaluate if the teams identified a viable problem, considering the time and effort constraints imposed by the course schedule and team formation; If the students understood the causes and impacts of the problem in question; If the teams defined the roles and responsibilities of each member in the problem solving process; If they planned and scheduled the necessary actions to initiate a EMS project. This cycle marked the beginning of the project, so its main focus was "planning".
- 2nd. Cycle (*Proposal of solutions*): this cycle had as main focus to evaluate the maturity of the students in the understanding of the problem from interactions with the real clients and teamwork, describing specifically one solution within a defined project scope. This cycle was responsible for the delimitation of one solution, therefore, focused on the "scope" of the product to be delivered.
- 3rd. Cycle (*Prototyping a solution*): The purpose of this cycle was to evaluate the ability of teams to prototype a solution, in accordance with the requirements of the real client and users. This cycle focused on the design of an IS solution, therefore, focused on the "system design".
- 4th. Cycle (*Delivery a solution*): finally, this last cycle had the objective of evaluating students' understanding of the problem solving process as a whole, as well as the proposed solution and the necessary requirements for its implementation and effective adoption. The aim of this cycle was to understand the "solution" as a whole.

It is important to emphasize that the definition of these cycles had as reference the problem solving process of managerial information systems defined in (Laudon and Laudon, 2004). From the objective of each cycle, it was possible to define the necessary evaluations, having as main reference the PBL-SEE assessment model (Santos, 2016), an integral part of the PBL framework. For this case, only the results of levels 1 and 2 of the PBL-SEE will be presented in this paper.

4.3 Checking

To develop the essentials skills the student assessment, recommended by PBL-SEE model was applied in accordance with the five perspectives (Content, Process, Output, Performance and Client Satisfaction). Table 1 shows the types of assessment conducted within each module, and highlights the instrument used for the assessment: subjective test, one with focus on process resolution concepts and other with focus on knowledge about the project decisions; the Meeting to start the Project (Kick-off); the Project monitoring meeting or remote monitoring (status report); the final presentation, to delivery the solution.

Table 1: Types of Assessment per Learning Cycle.

Individual Assessment (Summative)		
# Cycle	*Content*	*Performance*
1	-	-
2	1st subjective test	questions form
3	2st subjective test	questions form
4	-	-
Group Assessment (Formative)		

# Cycle	Process	Output	Client
1	Kick-off	Kick-off	Kick-off
2	1st status report	1st status report	1st status report
3	2nd status report	2nd status report	2nd status report
4	Final presentation	Final presentation	Final presentation

The 1st. Cycle and the 4th. Cycle were related to the initial and the end of the project steps, respectively. Thus, only the evaluations from the group perspective (Process, Output and client satisfaction) were applied. The individual evaluations of Performance and Content aspects are not adequate in these situations, when much information is missing or the project is already finalizing. As for the 2nd. and 3rd. cycles, all five perspectives (process, output, client satisfaction, performance and content) were applied. The results are presented and discussed in the following subsections. For the calculation of the students' overall performance in the course, it was used the following formula:

*20% * AA(Content) + 20% * AA(Process) + 20% * AA (Output) + 20% * AA(Performance) + 20% * AA(Client satisfaction),*

where "AA" corresponds to the arithmetic mean of the scores related to each perspective, when there is more than one score.

Regarding the Content perspective of the student assessment model, two subjective tests were applied in the 2nd. and 3rd. learning cycles.

The first test had the objective of the students' understanding of the problem solving process, regarding the implementation of a EMS for the respective real client. As a result, the general average of the class was 3.19, considering an interval of 1 to 5, with 57% of students with a performance equal to or greater than the desired average (equal to or greater than 3.5).

It is worth to emphasize that, on the 2nd. learning cycle, the teams had already structured the problem and delimited with greater clarity the scope of the solution. However, the results of this test showed that there was a difficulty in the teams to plan their projects, to define tasks and schedules compatible with their resources. This was happened because the students didn't define a consistent resolution process, which is a responsibility assumed by teacher in the traditional approach. For this, the content related to project management was reinforced.

The second test, held at the end of the 3rd. Cycle, had the objective of verifying the participation and contribution of each member in his/her team. The questions were also asked according to the resolution process, but the answers should be instantiated within the reality of each project. This test had a very interesting result, as it proved the students' maturity in conducting their projects and the different but consistent point of view that each one had on what his team was solving. From this context, it was also identified that the majority of students was active participant in their projects, all of them were engaged in their projects. The general average of the class reached 4.22, with 90% of the students with marks above the desired average. Table 2 shows the overall average of the teams from the perspective of Content in each test, with better performance for the teams T1, T3 and T6.

Table 2: Evaluations in the Perspective of Content.

Criteria	***T1***	***T2***	***T3***	***T4***
1º. Exam	4	3.375	3.1	3.17
2º. Exam	4	4	4.75	3.8
General averages:	4	3.68	3.9	3.5
Criteria	***T5***	***T6***	***T7***	-
1º. Exam	1.92	3.56	2.94	-
2º. Exam	3.25	4.62	4.6	-
General averages:	2.58	4	3.77	-

In the perspective of Performance, two exams were applied on the middle of second and third learning cycles. Eight competences were assessed: self-initiative, commitment, collaboration, innovation, communication, learning, planning and analysis, as shown in Table 3. Due to the subjectivity of this analysis, this perspective used a scale of five values, with the following meanings: (1) "did not meet expectations"; (2) "partially met them"; (3) "met them"; (4) "met them very well"; (5) "exceeded expectations". This review was conducted by the PBL/Technical tutor and applied in the self-assessment format and evaluation in pairs (known as the 180 degree evaluation), where each member of a team was rated by his/her colleagues, anonymously.

Since this was undertaken by means of an online research tool, sophisticated individual reports could be obtained for each student, which showed the results of the assessment of colleagues in his/her team and his/her own assessment in a consolidated and graphic way, for each assessment criterion, including subjective comments. From their individual report, the students can have a sense of their performance in teamwork in the view of their team members, highlighting their strengths and points of improvement.

Table 3: Evaluations in the Perspective of Performance.

Criteria	*T1*	*T2*	*T3*	*T4*
SELF-INITIATIVE	3.58	3.59	3.94	2.84
COMMITMENT	3.62	3.89	3.89	2.93
COLLABORATION	3.58	3.81	4.11	3.18
INNOVATION	3.32	3.27	3.78	2.84
COMMUNICATION	3.40	3.76	3.83	3.07
LEARNING	3.68	3.72	3.83	3.00
PLANNING	3.42	3.56	3.39	2.63
ANALYSIS	3.52	3.60	3.89	2.99
General averages:	3.52	3.65	3.83	2.94
Criteria	***T5***	***T6***	***T7***	
SELF-INITIATIVE	3.72	3.75	3.76	
COMMITMENT	3.84	3.88	3.50	
COLLABORATION	3.84	4.06	3,54	
INNOVATION	4.06	4.06	3.38	
COMMUNICATION	3.39	3.72	3.44	
LEARNING	3.89	4.06	3.48	
PLANNING	3.83	3.81	3.32	
ANALYSIS	3.78	4.13	3.52	
General averages:	3.79	3.93	3.49	

On analysing Table 3, it can be seen that teams T3 and T6 stand out with respect to the performance of their members, in the eight perspectives mapped. On comparing with the perspectives of Content, we see that there is a direct relationship between the best results of Performance especially in criteria Learning, Planning and Analysis, considered on the content exams.

The evaluations focused on group performance (Process, Output and Client Satisfaction) were applied in all learning cycles, conducted in the Status Report meetings, with the presence of the teacher (as a specialist in MIS), Technical tutors (as specialist in project management), PBL tutors and real clients.

In the perspective of “Process”, the teams were evaluated by a technical tutor, who monitored the projects during four meetings: one Kick-off, two Status Report (SR) meetings and the final presentation. At the SR meetings, each team always answered five questions: "What is the objective of your project?"; "What's the plan?"; "What has been done?"; "What are the strengths?"; and "What are the points of improvement?". As criteria for evaluation in this perspective, the following were defined: (1) Clarity in presentation; (2) mastery of the presentation; (3) Completeness when considering the five questions; (4) understanding of Planning. Each indicator could take on one value from a simple scale of five values: "1 - Insufficient; 2 - Regular; 3 - Good; 4 - Very Good; 5 - Excellent".

As to the perspective of Output, this was focused on analysis of the content of the presentations of the projects in the monitoring meetings. These analyses were conducted under the following criteria: (1) Context of the project; (2) Problem description; (3) Planned solution; (4) Value proposal; (5) Validation of the proposal. Once again, the same simple scale of five values was used. These evaluations were conducted by teacher.

The evaluation of client satisfaction was based on the following criteria: projection of confidence in interviews; understanding of the problems; clarity of presentation; quality of the solutions proposed; level of planning. This assessment used the same value scale as the perspectives of Process and Output, and was conducted by the client of the respective solution present in the Status Report meetings. Figure 2 summarizes the results of the teams in these three perspectives.

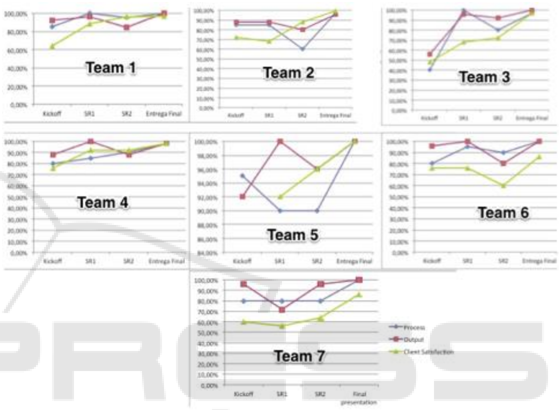

Figure 2: Evaluations in the Perspective of Process, Output and Client satisfaction.

Below is a brief description of each project developed by the teams:

Team 1 Project: Tool for corporate training.

Team 2 Project: Organization's maturity diagnostic tool for deploying management systems.

Team 3 Project: Tool for mapping departments and teams to create an interactive organization chart.

Time 4 Project: Knowledge management process and workshops on how to do knowledge management.

Team 5 Project: A game for corporate training.

Team 6 Project: Information system design to combat waste and loss of food products due to management and logistics issues related to products.

Team 7 Project: Software Development for Demand Management (Acquisition of Software / IT Services).

On analysing the graph in Figure 2, we see that the performance of most of the teams improved throughout the stages of the life cycle of the project. Turning to the performance of teams T2, T3 and T5, we moreover see a significant improvement between the 1st monitoring (Kick-off) meeting and the final delivery. We can also see the difficulty of the teams concern to Process aspect, as verified in content exams. Another interesting behaviour observed in this chart was the natural "relaxation" of the teams that obtain excellent performances, when we compare the results of SR 1 and SR 2 for both Process and Output aspect. It is common for teams to concentrate on other priorities when they see that the challenges were met in full at that moment, and thus this has an impact on future activities and hence their performances in the following reviews.

Finally, the results of the teams in Client perspective show us a strong alignment between teams and their respective client. It is worth mentioning, that the involvement of the real customer in the evaluation process is crucial to the PBL approach, given that the stakeholder who will benefit from the solution cannot be left aside. This was one of the points that the teacher most worked on after the kick-off of the project: namely, the need to bring the customer to the center of the project, keeping him/her continuously close to the processes and validating each stage of the project with him. This reinforcement led to greater performances throughout the project in this perspective as shown in Figure 2.

From the five perspectives of student evaluation (individual and group), radar-type graphics were generated, which summarized, in a visual way, the performance of each team. Figure 3 shows the four-team radars for illustration purposes. These graphics were generated twice, for 2nd and 3trd cycles.

These graphs represent well the profile of each team, highlighting their strengths and weaknesses. Each respective graph can be used by the team to identify points that need to be better managed within the learning process, such as the process of problem solving and validation of solutions; And by the

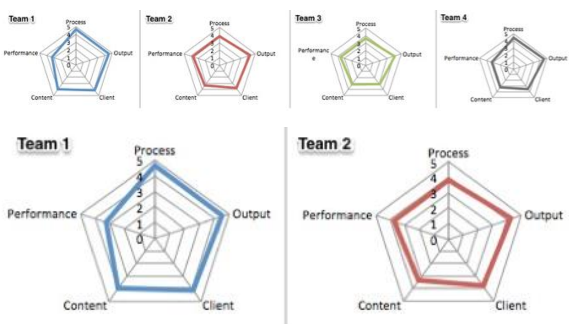

Figure 3: Student assessment by radar graphics.

student groups themselves, which, based on these results, can seek improvements related to teamwork, better distribution of internal tasks and individual needs for further study, among other initiatives.

4.4 Acting

The PBL-Test applications were carried out in two strategically defined milestones during the planning: 1) during the second cycle, after the kick-off of the projects; 2) the third cycle, after the first status report on the solutions. It was defined that, in these milestones, the students would already be able to present their perceptions before what they had already experienced with the process. Tests were applied by two PBL tutors (“guardian of the method”), verifying if the execution of the PBL process was in accordance with the PBL principles. Table 4 summarizes these results.

Table 4: PBL-Test results.

Principles of PBL	*1^{st} Evaluation*	*2^{nd} Evaluation*
1. Problem(s) at the core of the educational proposal.	0.82	0.88
2. Learner as the owner of the problem.	0.82	0.85
3. Authenticity of the problem or task.	0.94	1.00
4. Authenticity of the learning environment.	0.58	0.56
5. Learner drives the problem-solving process.	0.78	0.85
6. Complexity of the problem or task.	0.90	0.83
7. Assessment of how the problem was solved.	0.80	0.75
8. Reflection on the content learned and the learning process.	0.88	0.88
9.Collaborative and multidirectional learning.	0.90	0.90
10. Continuous Assessment.	0.90	0.90
Overall average:	*8.22*	*8.40*

For both assessments, an average percentage of 84.8% of class responses was maintained. As the purpose of the model, the PBL-Test considers that methodological deviations can be identified.

In summary, the results show that the level of maturity of the process was 2 (regular) for both applications, with a mean of 8.22 and 8.40. This score indicates that the teaching process evaluated is significantly adherent to the PBL principles. Given the results by principle, the PBL tutors, together with the pedagogical team, defined strategies that could improve the adherence of these principles to the process. For this, the results were presented and discussed with the tutors-mediated group in order to identify information that could substantiate the result.

Principles 4 and 5 were those that presented a lower score in the first application, compared to the others.

The main strategies established considered the promotion of reflection among the students so that they could perceive that the defined learning environment reflects real situations. The learning environment could not be characterized as a simulation, a situation assumed by the professor in face of their professional experiences, because the students deal directly with the clients that approved the demands, besides experiencing aspects inherent to the practice of project management (deadlines for delivering artifacts, costs, solution quality, process risks, among others). It is believed that the lack of adequate infrastructure to promote a collaborative learning environment is the factor that contributed to the result of the second application of the test, being less than the first one. This was due to the structure of the classroom for expository class (chairs lined up, professor's slate and digital projector), almost always requiring improvisation for group work.

For Principle 5, as a strategy to encourage self-directed learning, that is necessary to conduct the resolution process, it was decided that all teams would need to adopt a collaborative tool to manage activities and thus facilitate the conduct of the resolution process by the teams and monitoring by the technical tutor. One can see that the implemented strategies contributed to the adherence of the principles since the result was increased in the second application.

After the application of the second evaluation of the PBL-Test, students' impressions regarding the execution of the discipline were collected through a form. They were able to comment anonymously on what were the strengths and weaknesses. Listed below are some of these comments:

Strengths:

- Exit the comfort zone and stimulate the search for information.
- Feedback from clients and the teacher.
- Well-defined follow-up.
- Interaction with real clients.
- Consistency with the practical world

Weaknesses:

- Encourage more student participation with bonuses.
- Greater focus on theoretical knowledge, making it clearer how each theory interacts with projects.
- Increased number of clients to choose from students.
- Greater clarity in the definition of evaluation criteria.
- It improves the way the PBL methodology is presented.

5 CONCLUSIONS

While adopting the PBL approach has great potential for practice of professional learning, to manage this approach is not an easy task. With this challenge as a motivation, this paper describes the application of PBL in an Information Systems course, from a PBL Framework described in (Santos and Rodrigues, 2016) that allows to plan, execute, monitoring and improve the process of teaching and learning throughout its application.

Considering the planning stage, the elements of xPBL support the definition of a learning environment conducive to the PBL approach, considering its principles that highlight the need for authentic (relevant and complexity compatible with educational objectives) problems and a learning environment that reflects the labour market, with its resources such as specific human capital and follow-up processes.

In the execution step, one of the key points highlighted in the Framework is the need to define learning cycles, within a process that allows problem solving in a constructive and iterative way, promoting research activities and reflection on learning. These cycles should be aligned with specific educational objectives to be evaluated at the Check step.

The PBL-SEE model proposed for the Check step is responsible for the link between the objectives planned in the learning cycles, continuously evaluating each evolution of the teams from the perspective of the individual and the group, under different aspects that complement each other. This evaluation process, although it represents a great effort of time for the pedagogical team, has presented quite positive results. When assessing the student from different perspectives, his performance is shown in a transparent and fairer way.

Finally, the evaluation of the PBL approach throughout the course, using the PBL-Test model, has pointed out the main deviations of the approach, allowing improvements, either by reinforcing principles through practices, by promoting discussions with teams or by providing content recommendation.

As points of improvement for the Framework, we highlight the need to use information technology to support their models, as well as a more procedural view of their implementation. These initiatives are being developed by the authors of this work, from the proposal of a PBL planning tool based on canvas and instructional cards (Alexandre and Santos, 2018); a Learning Management System (LMS) to conduct the evaluations of the PBL-Test model (Oliveira and Santos, 2016) and; a website as a guide to support the application of the Framework, allowing the access to its artifacts and systems.

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